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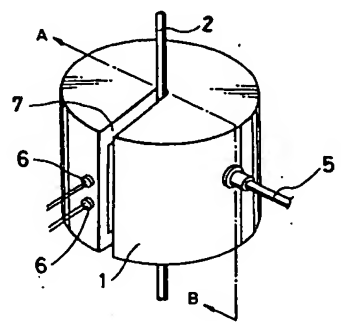
(54) DETECTOR FOR CONDUCTIVE SUBSTANCE MIXED IN STRING-LIKE MATERIAL.

(57) A detector for detecting conductive substances mixed in a string-like material sensitively, which is a cylindrical microwave cavity resonator (1) comprising a peripheral part (9) and two circular plates (10) covering the ends of the peripheral part. At least one of the circular plates has a cylindrical protruding part (4) at its center. In the peripheral part, an antenna (5) for the generation of discharge is provided. In the protruding part (4) a detection means (6) for discharge is provided. Paths (3, 8) or a notched part (7) for the string-like material to be measured which passes through a high electric field formed by the protruding parts and penetrate the cylindrical microwave cavity resonator are provided. When the string-like material containing very small metals passes through the protruding part of the microwave cavity resonator oscillating at a fixed frequency, discharges are generated by the strong electric fields concentrated on the very small metals. Since sounds, light, and electromagnetic waves are generated at this time, the very small metals can be detected sensitively with discharge detecting means such as a microphone, a photodetector and an antenna.

FIG. 1(A)



EP 0 468 057 A1

[Technical Field]

The present invention relates to a detecting apparatus of conductive material such as metal contained in a stringy material such as glass fibers comprising a cylindrical microwave cavity resonator.

[Background Art]

With development of high density mounting technology, severer requirements such as high withstand voltage have been imposed on printed circuit boards on which electronic devices are mounted in a high density more and more. This kind of printed circuit boards are formed by superposing a plurality of (e.g. seven) cloths, woven of glass fibers with paste, interposing epoxy resin between them.

If a high voltage is applied to printed circuit boards made of glass fibers containing minute metal pieces, discharges occur due to the minute metal pieces, so that it is impossible to get printed circuit boards with high withstand voltage if they use glass fibers containing minute metal pieces. Therefore it is necessary to use glass fibers without minute metal pieces for manufacturing high quality printed circuit boards. For this necessity development of technology to detect minute metal pieces contained in glass fibers has been wished in this technical field. The applicant of the present application already proposed in JP Pat. Kokai No. 63-145951 a microwave cavity resonator in which a protrusion is arranged in the center so that physical quantities of stringy materials can be precisely measured. As shown in Figs. 5A and B, the cylindrical microwave cavity resonator 1 comprises protrusion 4 on its center and space 3 for passing stringy material 2 arranged on the center of protrusion 4 and the wall of the microwave cavity resonator opposed to the protrusion.

Such microwave cavity resonator 1 allows to measure metals contained in stringy materials such as glass fibers. To do so glass fibers without metal pieces are first placed at space 3 and then resonance characteristic for the glass fibers are measured with a measuring instrument of resonance characteristic by scanning the frequencies of microwave supplied to the microwave cavity resonator 1 from antenna 5, which frequencies are changed by changing the voltage of the voltage control oscillator. Next if glass fibers containing metal pieces are placed at space 3 for measuring resonance characteristics, the resonance characteristics will be different from that of the glass fibers without metal pieces. Measuring of shifted amount in resonant frequency and decreased amount in resonance peak voltage enables not only to detect metals contained but also to measure the accurate amount of contained metal.

The method of detecting metals by the change of resonance characteristics in this manner has an advantage to obtain accurate measurement results, but it has a disadvantage that the total system costs too much because it needs a voltage control oscillator and a measuring instrument of the resonance characteristics. In case of glass fibers by which print circuit boards for high density assembling are manufactured, measuring the amount of contained metals is not necessary but only detection of contained metals is necessary. Furthermore in factories, glass fibers of several hundreds are manufactured at the same time and a detecting apparatus for contained metals is needed for every glass fiber, so that the total of the detecting apparatus costs enormously. Therefore one acceptable detecting apparatus of contained metals in a stringy material must be inexpensive. In this sense the measuring apparatus for physical quantities disclosed in Pat. Kokai No. 63-145951 has some disadvantage when the introduction of the apparatus to factories of manufacturing glass fibers is considered.

On the other hand, in case of glass fibers used for high density printed circuit boards only the problem is whether or not metals are contained in the glass fibers. From this point of view, the detecting apparatus of physical quantities, as disclosed in Pat. Kokai No. 63-145951, which can measure not only existence of metals but also accurate amount of contained metals is an unnecessarily accurate detecting apparatus as one used when manufacturing glass fibers.

[Disclosure of Invention]

One of objects of the present invention is to provide an inexpensive detecting apparatus of conductive materials which can accurately detect the existence of minute metal pieces contained the material to be measured such as stringy materials.

The present invention solves the above mentioned problem by providing a detecting apparatus of conductive materials contained in a stringy material comprising a cylindrical microwave cavity resonator having a circumferential portion and disks covering the both ends of the circumferential portion, which comprises a cylindrical protrusion arranged on the center of at least one of the disks, at least one antenna provided on the circumferential portion, a detecting means for discharge, and a pass for the stringy material to be measured arranged in high electric field region formed by the protrusion and penetrating the cylindrical microwave cavity resonator.

When detecting of conductive materials such

as minute metal pieces contained in stringy materials with the detecting apparatus of conductive materials of the invention, the microwave cavity resonator is made to resonate at a constant frequency by microwaves supplied from a discharge generating antenna. The microwave cavity resonator of the detecting apparatus of the invention comprises at least one protrusion at its center where the electric field is enhanced. The pass for the stringy materials to be measured penetrating the cylindrical microwave cavity resonator is arranged at a place where the the electric field is the highest. If minute metal pieces contained in the stringy materials locate at such place, the electric fields concentrate to the minute metal pieces, so that discharge will occur. At this time, since lights, sounds and electromagnetic waves are generated, discharges can be detected by a discharge detecting means such as a photodiode, a microphone, or a loop antenna. In this way metal pieces contained in the stringy materials can be sharply detected.

The only required function for the microwave generator used in the apparatus of the invention is to generate a discharge, so that it does not need an expensive voltage control oscillator which is essential for the prior method for measuring shift in resonance characteristic. Inexpensive magnetrons which are commonly used in consumer electric ranges are suitable enough for generators used in the system of the invention. In addition expensive measuring circuit for resonance characteristic, which is necessary for the prior measuring method, is not needed. Therefore the detecting apparatus of the invention is a very inexpensive apparatus which can be employed in a large quantity in factories of manufacturing glass fibers.

The apparatus characterized in that the two protrusions are opposed each other can supply larger electric fields to the stringy materials to be measured than the apparatus with only one protrusion.

In case of the apparatus characterized in that the pass is a vertical notch extending from the center axis to the circumferential portion, it is easy to set stringy materials to be measured on said apparatus because a user only need to move the stringy material to be measured from its circumferential portion to the center. In addition very few microwaves leak from said apparatus at the time of measurement, so that it is not necessary to cover the notch portion with dielectric after setting the stringy materials to be measured on the pass.

The apparatus characterized in that the pass is a vertical notch extending from the center axis to the circumferential portion has an advantage that setting stringy materials to be measured on said apparatus is easy. The apparatus characterized in that the pass is a penetrated hole including the center axis of the microwave cavity resonator and the apparatus characterized in that apertures are arranged on the circumferential portion where a straight line perpendicular to the center axis of the microwave cavity resonator hits, have both an advantage that microwaves leaked from the microwave cavity resonator at the time of measurement are fewer than ones in the apparatus without said notch.

[Brief Description of Drawings]

Fig. 1A shows the microwave cavity resonator of the invention in which a notch portion is arranged vertically,
Fig. 1B is a sectional view along line A-B in Fig. 1A,
Fig. 2A shows the microwave cavity resonator of the invention in which a notch portion is arranged horizontally,
Fig. 2B is a sectional view along line A-B in Fig. 2A,
Fig. 3A shows the microwave cavity resonator of the invention in which a penetrating hole is arranged vertically,
Fig. 3B is a sectional view along line A-B in Fig. 3A,
Fig. 4A shows the microwave cavity resonator of the invention in which apertures for the stringy material to be measured are arranged on the circumferential wall,
Fig. 4B is a sectional view along line A-B in Fig. 4A,
Fig. 5A shows the microwave cavity resonator of the prior art, and
Fig. 5B is a sectional view along line A-B of the microwave cavity resonator in Fig. 5A.

[Best Mode for Carrying Out the Invention]

The detecting apparatus of conductive material of the invention will be explained further with attached figures.

Example 1

The first example of a detecting apparatus of conductive material of the present invention will be explained with Figs. 1A and B.

The apparatus of the example comprises a cylindrical microwave cavity resonator 1 (inside diameter: 50 mm, outside diameter: 70 mm) at the center of which opposing cylindrical protrusions 4 with a diameter of 22 mm are arranged. The distance in the axial direction between internal walls of two disks 10 of the microwave cavity resonator 1 is 45 mm and the height of the protrusion 4 is 14 mm, so that separation between both protrusions 4

is 17 mm.

The microwave cavity resonator 1 is provided with notch portion 7 with a width of 4 mm and extending from the center of protrusion 4 to the circumferential portion 9 of the resonator. A user can easily set the stringy material on the center of the apparatus through such notch portion 7. Fig. 1B shows a sectional view along a broken line A-B in Fig. 1A on which the stringy material 2 is set.

As shown in Fig. 1A, the circumferential portion 9 of microwave cavity resonator 1 is provided with two photodiodes 6 near the notch portion 7 and a straight antenna 5. The antenna 5 is connected to a magnetron having an output of 10 W and a frequency of 2.45 GHz. The photodiodes 6 are arranged on a location such that light generated by discharges due to minute metal pieces contained in stringy material 2 can be detected.

For detecting metals contained in the stringy material 2 with this apparatus as shown in Fig. 1A, the stringy material should be placed at the place where the electric field is the largest, that is to say, at the center of the microwave cavity resonator 1. Next, microwaves with a frequency of 2.45 GHz and an output of 1 W is supplied into the microwave cavity resonator 1 through the antenna 5 so as to resonate. If there are minute metal pieces in the stringy material 2 under said condition, discharges with sounds and lights will be generated. The discharge is detected with the two photodiodes 6 arranged in different places. Stainless steel balls with a diameter of 0.2 mm and copper metal pieces with a length of 5 mm and a diameter of 10 micron meter contained in glass fibers could be detected with this apparatus.

In case of the apparatus of example 1, microwaves leaked from the notch portion 7 can be neglected under said resonance condition. Therefore there is no need to cover the notch portion 7 with conductor in order to prevent the leakage of microwave which is dangerous to a human body.

Example 2

The second example of the apparatus of the invention will be explained with Figs. 2A and B.

The apparatus in this example is provided with the notch portion 7 in the transverse direction. The two photodiodes 6 are arranged on the part of circumferential portion 9 facing on the notch portion 7.

Unlike the apparatus of example 1, microwaves leaked from the notch portion can not be neglected in this example. Therefore in order to prevent danger to human bodies the notch portion 7 should be covered with conductor after the stringy material being set on a desired position. The conductor is not necessarily a metal plate. A metal foil can also prevent the leakage of microwaves to the outside of the apparatus.

Example 3

The third example of the apparatus of the invention will be explained with Figs. 3A and B.

The apparatus in this example comprises penetrating hole 3 having a diameter of 4 mm arranged at the center axis of the protrusion 4 enabling the stringy material pass through.

Unlike the apparatus in examples 1 and 2, the apparatus in this example is not provided with the notch portion, so that microwaves do not leak, which results in the improvement of measurement accuracy.

Example 4

The fourth example of the apparatus of the invention will be explained with Figs. 4A and B.

The apparatus in this example comprises penetrating holes 3 having a diameter of 4 mm at both ends of the circumferential portion in such a way that the stringy materials pass through the center of the protrusion and a space formed by the two separated protrusions.

The apparatus has the same effect as one of example 3, and furthermore does not have disadvantage in example 3 that undesired discharges easily occur between the protrusions.

In the examples explained above, discharge states caused by minute metal pieces contained in the stringy material is detected by lights. However the discharge states can be detected with sounds collected by a microphone instead of lights. Furthermore discharge detection with electromagnetic waves by means of a loop antenna and a detector is possible. In this case, the frequency of the generated electromagnetic waves is different from the resonant frequency f_3. Therefore if the loop antenna and the detector are designed so as to detect frequency f_3, electromagnetic waves allow to detect minute metal pieces.

Furthermore those microwave cavity resonators described hereinbefore have two protrusions, but it is allowable that the resonator has only one protrusion so that the protrusion faces a flat wall.

[Industrial Applicability]

As explained above, the detecting apparatus for conductive materials of the invention is suitable to detecting conductive materials such as minute metal pieces contained in the stringy materials such as glass fibers.

Claims

1. A detecting apparatus of conductive materials contained in a stringy material comprising a cylindrical microwave cavity resonator having a circumferential portion and disks covering the both ends of the circumferential portion, which comprises a cylindrical protrusion arranged on the center of at least one of the disks, at least one antenna provided on the circumferential portion, a detecting means for discharge, and a pass for the stringy material to be measured arranged in high electric field region formed by the protrusion and penetrating the cylindrical microwave cavity resonator.

2. An apparatus as claimed in claim 1 characterized in that each disk has the protrusion and the two protrusions are opposed each other.

3. An apparatus as claimed in claim 1 or 2 characterized in that the detecting means is a photodiode.

4. An apparatus as claimed in claim 1 or 2 characterized in that the detection means is a microphone.

5. An apparatus as claimed in claim 1 or 2 characterized in that the detection means is a loop antenna.

6. An apparatus as claimed in any one of preceding claims characterized in that the pass is a vertical notch extending from the center axis to the circumferential portion.

7. An apparatus as claimed in any one of claims 1-5 characterized in that the pass is a semicircular notch of a transverse plane perpendicular to the center axis and extending from the center axis to the circumferential portion.

8. An apparatus as claimed in any one of claims 1-5 characterized in that the pass is a penetrated hole including the center axis of the microwave cavity resonator.

9. An apparatus as claimed in any one of claims 1-5 characterized in that apertures are arranged on the circumferential portion where a straight line perpendicular to the center axis of the microwave cavity resonator hits.

FIG. 1(A)

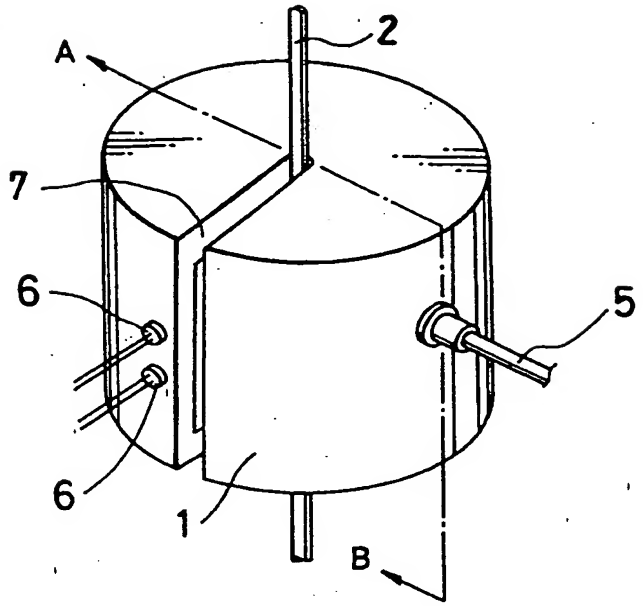


FIG. 1(B)

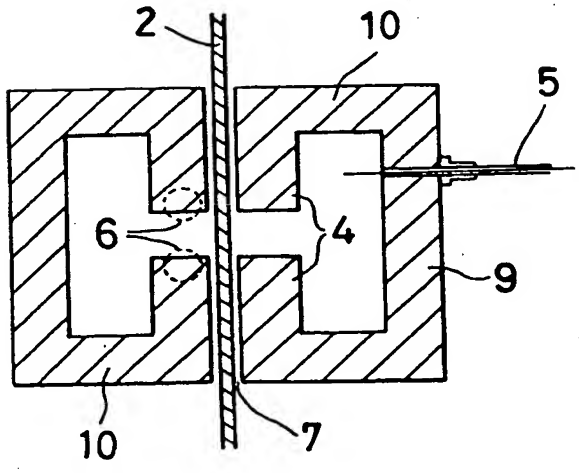


FIG. 2(A)

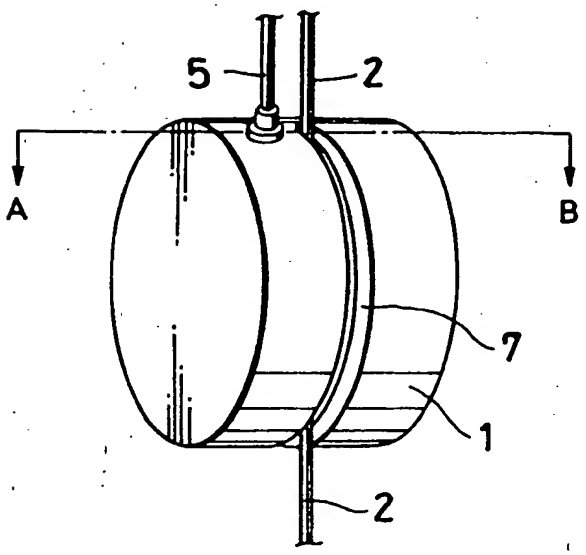


FIG. 2(B)

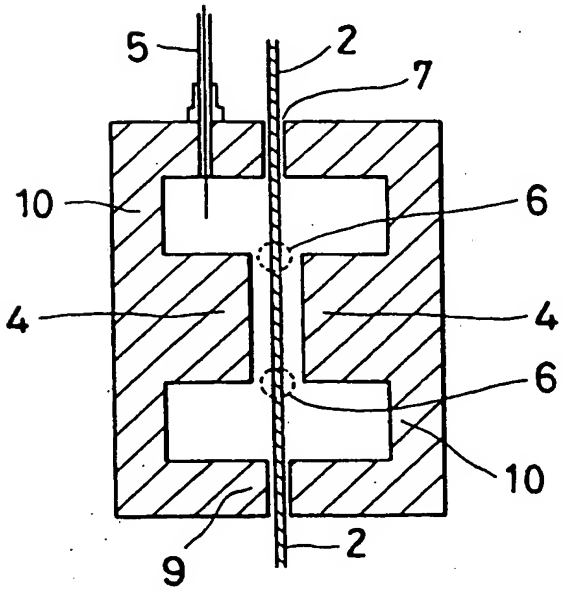


FIG. 3(A)

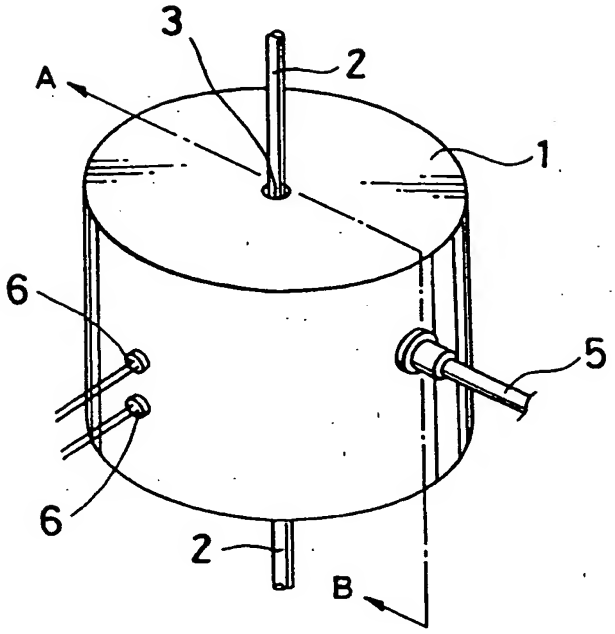


FIG. 3(B)

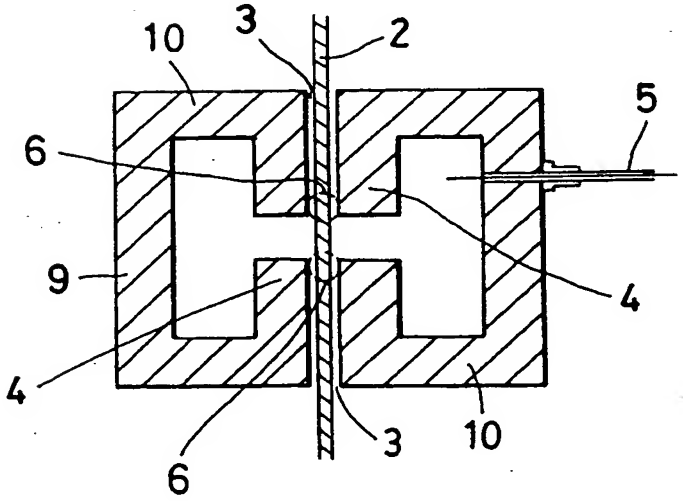


FIG.4(A)

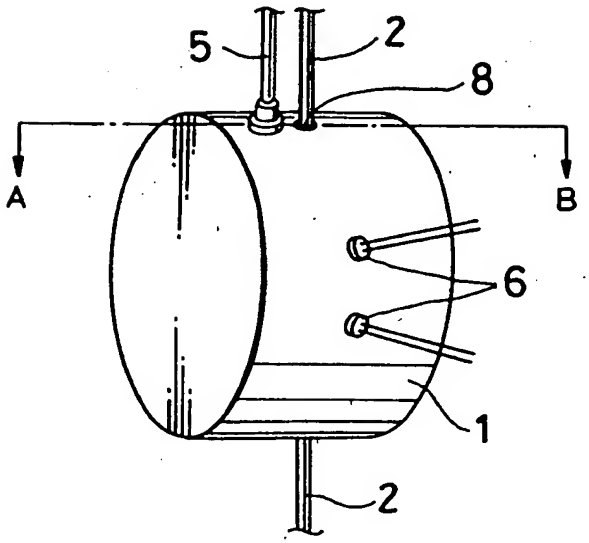


FIG.4(B)

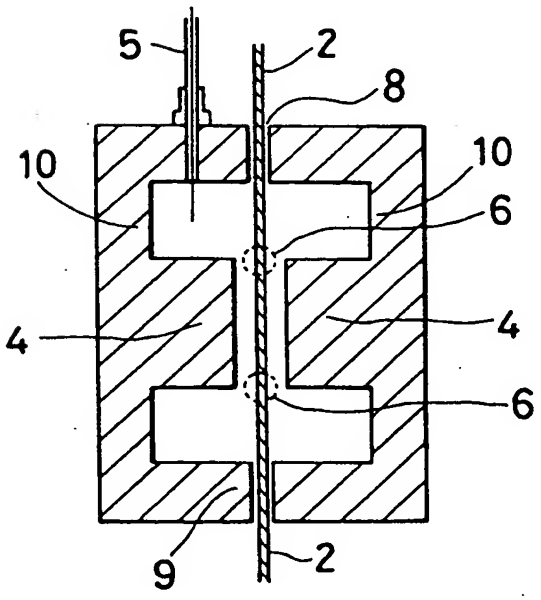


FIG. 5(A)

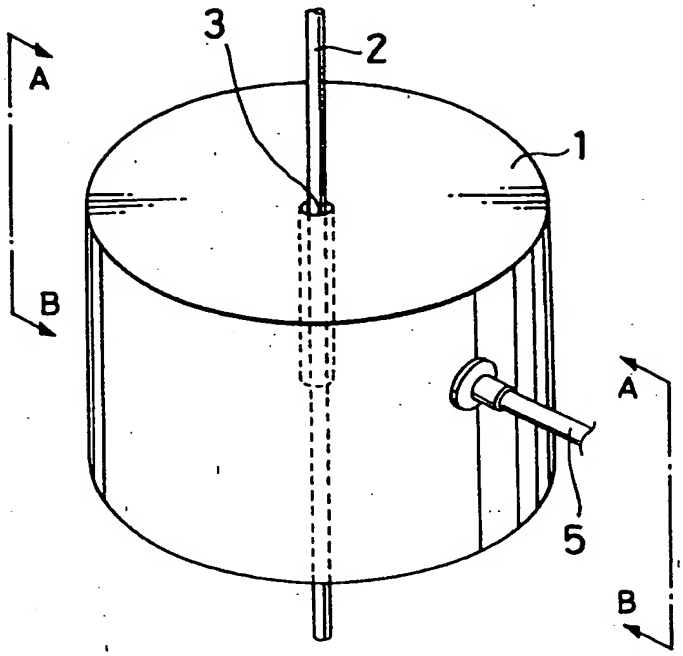
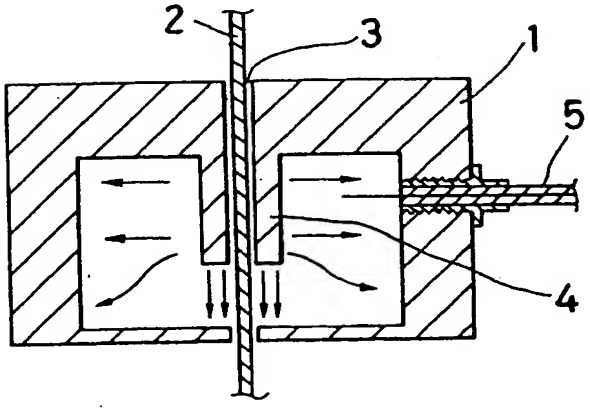


FIG. 5(B)



INTERNATIONAL SEARCH REPORT

International Application No PCT/JP91/00107

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl[5] G01N22/02

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	G01N22/02

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

Jitsuyo Shinan Koho	1926 - 1990
Kokai Jitsuyo Shinan Koho	1971 - 1990

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	JP, A, 57-165747 (Fujita Corp.), October 12, 1982 (12. 10. 82), (Family: none)	1-9

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
February 21, 1991 (21. 02. 91)	March 4, 1991 (04. 03. 91)
International Searching Authority	**Signature of Authorized Officer**
Japanese Patent Office	

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